"Smith, Steven D"
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06/20/2005 12:32 PM

To

Subject FW: SA2/GMCS - Step Test Hydraulic Conductivity Tech Memos

Nabil

Attached are tech memos from URS and GSI on their unsuccessful attempts to derive aquifer hydraulic conductivity from the step tests performed to assess sand content from the three Sauget Area 2 Groundwater Migration Control System extraction wells.

Steve

<<HydraulicConductivity_Let.pdf>> <<2898_GSI_K_Memo.pdf>>


HydraulicConductivity_Let.pdf


2898_GSI_K_Memo.pdf

URS

June 16, 2005

Mr. Richard Williams
Solutia Inc.
500 Monsanto Avenue
Sauget, Illinois 62206

Subject: Estimation of Hydraulic Conductivity (K) from the Step-Drawdown Pumping Tests at Site R

Dear Mr. Williams:

Following the completion of the step-drawdown pumping tests at Site R, URS attempted to analyze the data to estimate the hydraulic conductivity (K) of the American Bottoms aquifer in the vicinity of Site R.

The value of K is typically calculated indirectly by dividing the aquifer transmissivity (T) by the saturated thickness.

We considered using the Birsoy-Summers method to estimate T from the step-drawdown data. We also considered using data from the first step of the step-drawdown tests to calculate T using the Theis method for the analysis of constant-discharge tests. Both of these methods assume that the aquifer has infinite areal extent in all directions. Since this assumption is clearly invalid at Site R due to the presence of the barrier wall, these methods are inapplicable.

As an alternative, we attempted to analyze the constant-discharge data from the initial steps of certain tests using Stallman's curve-matching method for aquifers that have one or more straight impermeable boundaries. This method employs imaginary recharge wells to simulate the straight, impermeable segments of the barrier wall. When we applied this method, however, we were unable to obtain satisfactory matches between the type curves and the data curves.

In summary, URS was unable to derive a reliable K value from the step-drawdown pumping test data at Site R.

Please contact us if you have any questions or require additional information.

Very truly yours,

URS Corporation

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GROUNDWATER
SERVICES, INC.

TO: Mr. Bruce Yare, Solutia Inc.

FROM: Charles Newell and Shahla Farhat

RE: Hydraulic Conductivity of MDU/HDU in the Vicinity of the Sauget Area 2 Groundwater Migration Control System

BACKGROUND

As requested by Solutia Inc. (Solutia), Groundwater Services, Inc. (GSI) has evaluated the hydraulic conductivity calculation for combined MDU (middle hydrogeologic unit) and DHU (deep hydrogeologic unit) in vicinity of the Sauget Area 2 Groundwater Migration Control System (GMCS) capture zone. The hydraulic conductivity of the unit is needed to develop a control mechanism for pumping of the groundwater extraction wells that comprise the GMCS.

Groundwater modeling of the change in the water level step rate test conducted in March-April 2005 was used for this evaluation.

CHANGE IN WATER LEVEL STEP RATE TEST GROUNDWATER MODELING

The MODFLOW groundwater flow model (McDonald and Harbaugh, 1988) was used to see if a numerical groundwater model could be used to provide a more precise estimate of the hydraulic conductivity of MHU/DHU in the vicinity of the Sauget Area 2 GMCS. The MODFLOW model developed for Site R and described in the *Interim Groundwater Remedy Design Basis* (GSI, 2002) and *Sauget Area 2 Site R MODFLOW Model Calibration* (GSI, 2003) was used as the basis for this modeling study. The existing model was based on literature values for hydraulic conductivity, modified by a steady-state calibration step.

For this evaluation, the MODFLOW model was run in a transient mode and the calculated heads were compared to the measured heads at four piezometers: P1-inside, P2-inside, P3-inside and P4-inside. Key model attributes, assumptions, and input data for the MODFLOW model are listed below:

- A finite-difference grid with 60 ft by 60 ft cells in the vicinity of Site R was used with cell size gradually increasing with distance from Site R. The model covered an area of 57 square miles (approximately 3 miles north, 4 miles south, 6 miles east and 2 miles west of Site R in Sauget Area 2).

- Three layers were used in the model: i) an unconfined Shallow Hydrogeologic Unit with a porosity of 0.30; ii) a convertible confined/unconfined Middle Hydrogeologic Unit; and iii) a confined Deep Hydrogeologic Unit.

- The Mississippi river was modeled using MODFLOW's river package. For steady state runs, a river level stage of 390.8 ft MSL was used for the river in the study area based on data collected at 11:24 a.m. on April 9, 2005. For transient model

runs, a river level stage ranging from 371.4 to 392.4 ft MSL was used for the river in the study area based on data collected from 8:00 a.m. on March 21, 2005 through 3:30 p.m. on April 12, 2005.

- Constant head cells were used in the model to represent the eastern boundary of the modeled area (the bluff line) based on "steady-state" constant head elevations used in a regional groundwater flow model developed by Clark (1997).

- A surface infiltration rate of 7.8 inches per year was used in the model to represent infiltration from rainfall (Schicht, 1965).

- A regional pumping center of 4167 gpm, assumed to be withdrawn from all three layers, was established in the model to represent ongoing highway dewatering projects in the East St. Louis area (Ritchey and Schicht, 1982).

- Hydraulic conductivity data compiled by Schicht (1965) were used as the initial hydraulic conductivity in the model for the Middle and Deep Hydrogeologic Units. Isoptropic conditions were assumed in the x and y direction, following the approach used by Clark (1997). A Kx/Kz ratio of 500 was used for the Shallow unit and a ratio of 50 was used for the Intermediate and Deep units.

- The Mississippi river was modeled using MODFLOW's river package. An average river level stage of 391 ft MSL was used for the river in the study area based on 1933 to 2001 monthly river stage data (Attachment 10, *Interim Groundwater Remedy Design Basis*).

- A primary storage coefficient of 0.09 ft^{-1} and specific yield of 0.09 were used during the transient simulations based on data compiled by Schicht (1965).

- Reported pumping rates for wells EW-1, EW-2, and EW-3 during the step-rate performance tests (ranging from 0 to 700 gpm per well) were used in the model for the interval between March 21 to April 12, 2005.

The transient simulation focused on trying to reproduce the observed drawdown on April 9, 2005, when well EW-2 was pumped at 700 gpm for 24 hours, producing drawdowns of 0.6 ft, 1 ft, 1 ft, and 0.4 ft in piezometers PZ-1, PZ-2, PZ-3, and PZ-4. Despite varying hydraulic conductivity, storativity, river levels, upgradient water elevations (constant head), and pre-March 21 pumping rates, the transient model was unable to accurately simulate the observed water levels and drawdowns in the four piezometers during the step-rate performance test.

C. Newell and S. Farhat

GROUNDWATER
SERVICES, INC.

REFERENCES

Clark, G.R., 1997. *American Bottoms Regional Ground-Water Flow Model*, Illinois Department of Natural Resources, Office of Water Resources, Springfield, Illinois.

Groundwater Services, Inc., "Sauget Area 2 Site R MODFLOW Model Calibration", Houston, Texas, November 24, 2003.

Groundwater Services, Inc., "Interim Groundwater Remedy Design Basis" in "Focused Feasibility Study Interim Groundwater Remedy Sauget Area 2 Sites O, Q, R and S", Solutia Inc., St. Louis, Missouri, March 31, 2002.

McDonald, M.G. and A. Harbaugh, 1988. *A Modular Three Dimensional Finite-Difference Groundwater Flow Model*, Techniques of Water Resources Investigations 06-A7, USGS.

Ritchey, J. D. and R.J. Schicht, 1982. "Ground-Water Management in the American Bottoms, Illinois," State, County, Regional, and Municipal Jurisdiction of Ground-Water Protection, Proceedings of the Sixth National Ground-Water Quality Symposium, Atlanta, Georgia, Sept. 14-22, 1982, National Water Well Association.

Schicht, R.J., 1965. *Ground-Water Development in East St. Louis Area, Illinois, Report of Investigation 51*, Illinois State Water Survey, Urbana, Illinois.

TECHNICAL MEMORANDUM **CH2MHILL**

Comments on the May 13, 2005, Interim Operating Period 1 Tech Memo, Sauget Area 2 Groundwater Migration Control System

PREPARED FOR: Nabil Fayoumi / USEPA

PREPARED BY: CH2M HILL

COPIES: Sandra Bron / IEPA

DATE: June 23, 2005

On behalf of the U.S. Environmental Protection Agency (USEPA), CH2M HILL has reviewed the revised Interim Operating Period 1 Tech Memo (IOP-1 TM), dated May 13, 2005, for the Sauget Area 2 Groundwater Migration Control System (GMCS). CH2M HILL's comments on the revised IOP-1 TM are provided in this memorandum.

Because the USEPA, Illinois EPA (IEPA), Solutia, and Monsanto have agreed to update the subject document after the completion of a second 90-day interim operating period (IOP 2) for the GMCS, we have limited our comments to those that apply to the document that will be submitted following IOP 2.

Background

An original version of the IOP-1 TM was submitted to the USEPA and IEPA (Agencies) on April 1, 2005. On April 20, 2005, a meeting was held between Solutia, Monsanto, and the Agencies to discuss the IOP-1 TM and define the path forward for the GMCS. During the meeting, Solutia and Monsanto agreed to install additional piezometers (the locations of which are documented in the revised IOP-1 TM) and begin IOP 2 following the installation of the new piezometers and transducers. Solutia and Monsanto agreed to update the IOP Tech Memo to incorporate the April 20 meeting discussions and the additional data that would be collected during IOP 2.

USEPA's comments on the IOP-1 TM were provided in a summary of the April 20 meeting. Solutia submitted a revised version of the IOP-1 TM on May 13, 2005.

General Comments

1. The revised IOP-1 TM does not discuss the potential for bedrock flow or a vertical component of groundwater flow into the underlying bedrock. These issues were discussed during the April 20 meeting and should be addressed in the GMCS deliverable that is prepared following the completion of IOP 2.
2. During the April 20 meeting, the meeting participants discussed groundwater elevations that were measured during step-drawdown tests at Site R in March and April 2005. In the western portion of Site R, some wells consistently registered higher-than-expected groundwater elevations during these tests. An assessment of the step-drawdown test data should be included in the GMCS deliverable that is prepared following the completion of IOP 2.

Specific Comments

1. **Introduction** - The April 20, 2005, meeting between the Solutia and the Agencies should be referenced in the introduction to the revised Tech Memo. The document should acknowledge that the April 1 IOP-1 TM was revised per the discussions during the April 20 meeting.

2. **Page 4, Third Paragraph** - "This observation demonstrates that the Sauget Area 2 Groundwater Migration Control System could not be operated to achieve the ROD requirement for zero or negative gradient across the barrier wall under low river stage conditions even when pumping at maximum system capacity." This statement may not be correct; the system was not operated in a manner to anticipate rapid river level decline.

3. **Page 5, Flow Velocity Analysis** - This evaluation of flow velocities both on the interior of the wall and through the wall is flawed; however, the premise that velocity interior to the wall is orders of magnitude greater than velocity through the wall is appropriate. The gradient across the wall is miscalculated because it assumes head loss across the whole distance between the paired piezometers, when 99 percent of the head loss would occur across the thickness of the wall given the low permeability of the wall quoted in the

report. Also, the estimate of flow interior to the wall is overestimated because it assumes horizontal flow. Flow towards the extraction wells will not be horizontal. The discussion also does not recognize the role of molecular diffusion in contaminant transport through the wall.

4. **Page 7, Second Paragraph** - The concept of starting the IOP-2 with the K value of 0.1 centimeters per second (cm/sec) (285 feet per day [ft/d]) is appropriate. However, the distance between the ends of the two wing walls is 2,100 feet (ft), not 2,000 ft as stated in the IOP-1 TM. Changing this value consequently affects the input parameters for the GMCS control algorithm based on Darcy's Law. The discharge area utilized should be 210,000 ft^2 and not 200,000 ft^2.

5. **Page 7, Last Paragraph** - The usage of upgradient and downgradient in this paragraph is confusing and should be changed to east and west. However, we agree that it is appropriate that the GMCS can be shut down when the gradient indicates flow to the east due to high river levels.